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PLANT PATHOLOGY TO-DAY

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BUREAU OF PLANT INDUSTRY

THAT plant pathology in America has passed through its pioneer period and is now entering on a period of increased activity, broader scope, and greater usefulness is evident to all who have followed its recent development. In the words of Galloway,¹ who was one of the early workers and who has been closely associated with the growth of phytopathology in this country for the past thirty years, "For nearly a quarter of a century the study of plant pathology in this country was without very broad or definite aim or object." The condition described was due largely to the fact that the development of the subject in this country has been largely determined by economic and political conditions and demands rather than by any well-conceived and directed plans of the plant pathologists.

Plant pathology as a special subject of study and investigation in this country was taken up chiefly by the United States Department of Agriculture and the state experiment stations. At that time the work was necessarily restricted, the available knowledge of the subject small, the demands for immediate practical results large and the workers few. Notwithstanding these restrictions and the imperative demands for immediate results, many important discoveries of fundamental value were made, for example, the discovery that bacteria² caused plant disease and that the bacteria may be carried by insects.³

This was distinctively the utilitarian period in the development of the subject. During this economic or utilitarian period much time was necessarily devoted to spraying experiments, describing and cataloging pathogens and other fungi, and laying the foundation for more thorough and fundamental re-

¹ Galloway, Beverly T., "Some of the Broader Phytopathological Problems in their Relation to Foreign Seed and Plant Introduction," *Phytopathology*, 8: 87-97, 1918.

² Burrill, T. J., "Report on Botany and Vegetable Physiology—Pear-blight," *Trans. Ill. State Hort. Soc.*, N. S., 11: 114, 1877, and 12: 80, 1878; Arthur, J. C., "Proof that Bacteria are the Direct Cause of the Disease known as Pear Blight," *Bot. Gaz.*, 10: 343-345, 1885.

³ Waite, M. B., "Results from Recent Investigations in Pear Blight," *Bot. Gaz.*, 16: 259, 1891.

searches. The demands for immediate practical results and the application of pathological knowledge have continually tended to exceed the output of the necessary fundamental research and exact knowledge and have tended to encourage superficial work and the drawing of conclusions from too little evidence. The great demand for men and for practical applications of the science has also tended to encourage hasty preparation and insufficient training. The notable achievements in the field during the period have been due to the importance of the problems attacked, and to the skill of the individual investigators rather than to definite and coordinated plans of work. So striking indeed were the discoveries of the earlier pathological investigators in this country, and so important their results in the control of plant diseases that recent workers have tended too generally to follow the lines laid down by their predecessors, lines which had proven profitable in the past and give promise of results of more or less importance in the future.

In part then as a result of notable successes in certain directions and in part for economic and political reasons, the plant pathologist has had a rather restricted field of activity, not only as to the area in which he worked and as to the host plants investigated, but in particular as to methods of work and as to the aim and subject-matter of his studies.

The geographic limitations of the work were particularly unfortunate in that they were not the natural limitations of crop or climate, but the artificial ones of state and national boundaries. There was also a lack of cooperation and coordination of work. Pathologists in adjacent states investigated related problems with too little interchange of views. Foreign visits and studies have been too few and too short and have not been followed by sufficient work at home, as is indicated by the fact that there has been but little publication on the work of American pathologists in foreign countries. In this hemisphere tropical pathology has been, when the agricultural importance of the regions is considered, all but neglected.

It is natural and desirable that the study of plant pathology should be centered on plants of great economic importance. Scientifically and in the long run economically it would be of great value if the diseases of wild plants could be thoroughly investigated, especially those closely related to important cultivated plants.

Equally restricted have been the lines of attack followed when a new disease was to be studied or a familiar one attacked in a new area. To find a plant or plant part with evident ab-

normalities, to describe the condition, to isolate an organism from the affected parts, to grow this organism in pure culture and describe it, to produce an abnormal condition by inoculation with this organism and to prevent or reduce the abundance of the disease by spraying, these things were usually considered sufficient.

The field of the plant pathologist has been largely limited to the production phases of the important crops he has chosen for his work. By seed treatment and by spraying, by crop rotation and soil treatment, he has assisted the farmer in producing a crop and there he has stopped. The student of apple diseases, for instance, has taken his results and ceased his work when the crop was harvested, leaving the study of the important and far-reaching changes between field and consumer largely to the pomologist, the commercial cold-storage man, the retail grocer and the board of health. Forest pathology fortunately has never been thus limited in its outlook; following the able example of Hartig,⁴ the study of the diseases of structural timber and the methods of its preservation have been considered as truly a part of forest pathology as the study of leaf spots and other parasitic diseases.

In addition to these self-imposed restrictions there have also been in some cases the additional restrictions of administrative organization. Phytopathological problems were first attacked from the standpoint of the parasites producing diseases. This led to devoting the greater part of the time and effort of the investigator to the parasite, with a resulting neglect of the host and its very important relations. It also led in many cases to the idea that plant pathology included only troubles caused by "germs" or parasites instead of all abnormal physiological conditions by whatever cause induced.

Recognizing that this method of handling the subject was not an entirely satisfactory one, work was organized and divided largely on the basis of the economic host plants involved. This division of the subject has many disadvantages from a strictly scientific standpoint. In the case of parasites attacking several hosts it is necessary to study them in their relations to all their hosts in order to fully understand them and determine their relationships and pathogenic characteristics and to most effectively devise methods of control.

The most recent attempt at the classification of the subject

⁴ Hartig, R., "Die Zersetzungserscheinungen des Holzes der Nadelholzbaume und der Eiche," Berlin, 1878.

is according to the physiological effects upon the host. This has much to be said for it, but it also has its limitations.

The ideal method of attacking a pathological problem depends upon the nature of the specific case and should be interfered with as little as possible by system of classification or administrative arrangement. If it be a disease caused by a fungus the life history, relationship and physiological characteristics of the parasite must be studied, also the host reactions and relations under various environments. If the causal organism is found to attack other hosts it should be studied in its relation to these hosts also, whether they happen to be fruits, or vegetables or forest trees.

As a result of these limitations of the field, largely self-imposed by the pathologist, some of the most striking and valuable recent contributions to the science have been made by investigators who were not professionally, at least, plant pathologists. The work of Morse⁵ on the cause and nature of the deterioration of asparagus after cutting, the researches of Allard⁶ on the mosaic diseases of tobacco, the control of blue mold on oranges by Powell,⁷ and of lettuce drop by Ramsey and Markell,⁸ and the discovery by Meyer⁹ that the chestnut bark disease was native in China and Japan are cases in point.¹⁰

During the past decade, marked by the establishment of departments of plant pathology in some of our universities and the organization of the American Phytopathological Society, with its journal, "Phytopathology," there has been a marked change in the attitude of plant pathologists toward their work. Recent epidemics of diseases introduced from foreign countries have emphasized and attracted attention to the very important

⁵ Morse, F. W., "Experiments in Keeping Asparagus after Cutting," Mass. Agricultural Experiment Station Bull. 172, March, 1917.

⁶ Allard, H. A., "Some Properties of the Virus of the Mosaic Disease of Tobacco," *Jour. Agri. Res.*, 6: 649-674, July, 1916. (And other papers in the same journal.)

⁷ Powell, G. H., "The Decay of Oranges while in Transit from California," Bu. Plant Ind. Bull. 123: 1-75, 1908.

⁸ Ramsey, H. J., and Markell, E. L., "The Handling and Precooling of Florida Lettuce and Celery," Bu. Plant Ind. Bull. 601, 1917.

⁹ Fairchild, D. G., "The Discovery of the Chestnut Bark Disease in China," *Science*, N. S., 38: 297-299, 1913.

Shear, C. L., and Stevens, Neil E., "The Discovery of the Chestnut-blight Parasite (*Endothia parasitica*) and Other Chestnut Fungi in Japan," *Science*, N. S., 43: 173-176, 1916.

¹⁰ Throughout this paper no attempt is made at full citations of literature. The papers mentioned are merely by way of illustration. Further examples will occur to any one familiar with the subjects and would be useless to others.

international and cosmopolitan aspects of the subject and the need of a greater knowledge and better provisions to prevent the introduction of new parasites and diseases into this country. A greater breadth of view and to some extent a new spirit are apparent. There is evidence on the one hand that plant pathologists are realizing the obligation laid upon them to extend their studies to wider fields of activity and service and on the other hand there is a new spirit of cooperation among pathologists and students in closely related fields of research.

A WIDER FIELD

In the present awakening of phytopathologists to the real importance and extent of their field most of the self-imposed restrictions are disappearing. Investigators supported by state and federal funds still confine their attention chiefly to single areas, but cooperative effort has widened until we find the pathologists of Massachusetts joining with those of California in the study of a disease of cauliflower¹¹ and Faucett¹² is able to publish a comparative study of the citrus diseases found in California, Florida and the West Indies. A genuine international Phytopathology¹³ was well under way when interrupted by the present war and we find Galloway (I, p. 90) stating as the first of the fundamentals of a new phase of plant pathology, "The work is international."

While pathological research is still confined largely to cultivated plants of economic importance, attention is being given at least to the diseases of newly introduced plants (I), especially to plants of potential economic importance. Work of this type is Harter's¹⁴ study of the storage rot of the dasheen. Scientific data of the greatest future importance will be accumulated if accurate records are preserved of the changing pathological relations of a plant during the period it is being brought under cultivation and its area of cultivation is being extended. No better present opportunity offers than a study of the diseases

¹¹ Further illustrations of this type of cooperation may be found in Allen, E. W., Wilcox, E. V., Schulte, J. I., "Work and Expenditures of the Agricultural Experiment Stations," 1916, Part I, pp. 18 and 19, Washington, 1918.

¹² Fawcett, H. S., "Citrus Diseases of Florida and Cuba compared with those of California," University of California Publications, Bull. 262, 1915.

¹³ Shear, C. L., "Some Observations on Phytopathological Problems in Europe and America," *Phytopathology*, 3: 77-87, 1913.

¹⁴ Harter, L. L., "Storage-rots of Economic Aroids," *Jour. Agri. Res.*, 6: 549-571, 1916.

of the blueberry, now chiefly a wild plant, but already under cultivation and bidding fair to be of considerable economic importance.¹⁵

As the range of host plants investigated is being widened, so also are the phases of pathology which are being studied. The varied lines of attack on plant-disease problems evidenced in recent publications indicate that plant pathology now includes a wider range of interest than ever before. The chemical changes produced in the host by fungus parasites,¹⁶ oxidation in healthy as compared with diseased plant tissue,¹⁷ the relations between climate and disease,¹⁸ the importance of birds¹⁹ and insects as disseminators of fungus spores,²⁰ and even the relation between the diseases of plants and those of man,²¹ are being investigated.

In particular there is evidence that pathologists are no longer restricting their investigations to production problems. Brooks and Cooley²² are studying the diseases of apples in storage. The importance of plant pathology in its relation to the loss of perishable fruits and vegetables in transit has been recognized.²³ The somewhat artificial and arbitrary boundaries

¹⁵ Coville, F. V., "Directions for Blueberry Culture," U. S. D. A. Bull. 334 (Professional Paper), 1915.

¹⁶ Hawkins, Lon. A., "Effect of Certain Species of *Fusarium* on the Composition of the Potato Tuber," *Jour. Agri. Res.*, 6: 183-196, 1916. (And earlier papers cited therein.)

¹⁷ Rose, D. H., "Oxidation in Healthy and Diseased Apple Bark," *Bot. Gaz.*, 60: 55-65, 1915.

¹⁸ Stevens, Neil E., "Temperature of the Cranberry Regions of the United States in Relation to the Growth of Certain Fungi," *Jour. Agri. Res.*, 11: 521-529, 1917. (And earlier papers cited.)

¹⁹ Heald, F. D., and Studhalter, R. A., "Preliminary Note on Birds as Carriers of the Chestnut Blight Fungus," *Science*, N. S., 38: 278-280, 1913.

²⁰ Gloyer, W. O., and Fulton, B. B., "Tree Crickets as Carriers of *Leptosphaeria coniothyrium* (Fckl.) Sacc. and Other Fungi," New York (Geneva) Agri. Exp. Sta. Technical Bull. No. 50, 1916.

Gravatt, G. F., and Posey, G. B., "Gipsy-moth Larvæ as Agents in the Dissemination of the White-pine Blister-rust," *Jour. Agri. Res.*, 12: 459-462, 1918.

²¹ Smith, Erwin F., "Studies on the Crown Gall of Plants; its Relation to Human Cancer," *Jour. Cancer Research*, 1: 231-258, pls. 1-25, 1916.

²² Brooks, Charles, and Cooley, J. S., "Temperature Relations of Apple-rot Fungi," *Jour. Agri. Res.*, 8: 139-164, 1917 (and subsequent papers in the same journal).

²³ Coons, G. H., and Nelson, Ray, "The Plant Diseases of Importance in the Transportation of Fruits and Vegetables," Circular 473-A American Railway Perishable Freight Association. Chicago, February, 1918.

Shear, C. L., "Pathological Problems in the Distribution of Perishable Plant Products." *Memoirs Brooklyn Bot. Gard.*, 1: 415-422, pls. ix-xi, 1918.

of the pathologist's work have hindered their entering this important field. Credit is due the pomologists for first attacking the problem of the losses occurring in handling and transportation. Many pathological questions, however, are involved in this work, and a thorough knowledge of the fungi concerned, as well as of the abnormal physiology of the plant products under different conditions, must be obtained. A significant incident in this connection was the appointment in 1917 of a plant pathologist by the Illinois Central Railway. Almost simultaneous and of equal significance in a quite different field was the appointment of a plant pathologist by the American Smelting and Refining Company.

On the establishment of the Food Products Inspection Service by the Bureau of Markets,²⁴ the chief of that bureau, Mr. Charles J. Brand, requested the detail of plant pathologists to assist in the work. Pathologists were quick to realize their opportunity and have been active in assisting in the work since its establishment.²⁵ Partly as a result of this, and partly as a result of the world food shortage which called attention sharply to the fact that, at a conservative estimate, thirty million dollars worth of fruits and vegetables are annually lost between field and consumer in this country, the study of diseases of fruits and vegetables in the market is already assuming importance. The phytopathology of the future will not stop when the crops have been harvested, but will extend until the food products are eaten.

There is another source of encouragement for pathologists in the fact that there is a rapidly growing appreciation of the scope and value of their work on the part of the general public and the agencies which provide the financial support for their work. In this connection there is need of greater publicity among city residents and consumers. They should know something of the scope, purpose and practical utility of plant pathology and its intimate connection with their food problems. Millions of dollars, worth of perishable plant foods are destroyed each year in city homes because of lack of appreciation of some of the simplest principles of plant pathology.

²⁴ Service and regulatory announcements No. 28. Bureau of Markets, U. S. Department of Agriculture. Issued October 31, 1917.

²⁵ Shear, C. L., "Pathological Aspects of the Federal Fruit and Vegetable Inspection Service," *Phytopathology*, 8: 155-160, 1918.

TEAM WORK

There is no single characteristic by which the new plant pathology is and will be better distinguished than that of team work among investigators. The magnitude of the problems and the angles from which they must be attacked place them out of the reach of a single investigator. We may confidently expect organized "teams" to attack pathological problems in the future; not a group of assistants around a single leader but investigators of training and recognized ability in different lines, each of whom will attack the problem from his own point of view, finally coordinating and combining the results. Such an organization was temporarily formed in the study of the chestnut bark disease.²⁶ In this case foresters, mycologists, plant physiologists, entomologists and geologists united in attacking a single problem.

A striking example of what may be accomplished by team work is furnished by the workers in Blackman's laboratory who,²⁷ attacking a problem of great scientific interest from several angles, have contributed notably to our knowledge of the physiology of parasites. In the future we may expect to find mycologists, plant physiologists, and ecologists uniting with chemists, plant breeders, refrigeration experts, entomologists, horticulturists and meteorologists in the solution of problems of plant pathology. With this will go the freest and frankest interchange of ideas among plant pathologists themselves.

Pathologists are coming to realize that cooperation and co-ordination must be the watchwords of plant pathology as they are coming to be the watchwords in every line of human activity and endeavor. Any one familiar with pathological problems as they present themselves to-day can not fail to realize that no individual however broad his training, or whatever the time and facilities at his disposal, can hope to solve unaided the larger problems now needing attention.

The old idea which has been too prevalent in the past, that the individual investigator may by discovery, preemption or any other means acquire property rights in a scientific problem which will prevent any one else from attacking it, is being abandoned. The advancement of science and the benefit of mankind should be the primary aim and purpose of the pathologist. We are coming to realize that the end is more important

²⁶ The Publications of the Pennsylvania Chestnut Tree Blight Commission, Harrisburg, Pa., 1915.

²⁷ Brown, William, "On the Physiology of Parasitism," *New Phytologist*, 16: 109-127, 1917.

than any individual credit, honor or distinction. The all-important question is, how can the problems be solved in the quickest and most effective manner and the results be made most readily available.

Perhaps the most typical manifestation of the new spirit of cooperation is the creation by the American Phytopathological Society of the War Emergency Board of American Pathologists.²⁸ This board, made up of representative pathologists from different parts of the United States, is effectively engaged in uniting the efforts of plant pathologists on the phases of the great problems of food production and preservation which plant pathologists are peculiarly fitted to solve.

The work of this board may be more properly discussed at a later date, when its activities have produced the important tangible results which are in prospect. It is mentioned here as a recognition on the part of American phytopathologists that their science is, and should be, of great and general usefulness. It is not a science for special interests or special industries. Mankind is absolutely dependent on plant food, and reducing the loss of this plant food both on the farm and on its way to and in the hands of the consumer is the duty of the plant pathologist; a duty which in such a crisis as the present becomes imperative and vital.

²⁸ "News Items," *Torreya*, 18: 40, 1918.